

video game such as **FIG. 5**, where z range could be 5 meters or more, the angle A and the base line would be less, to allow a larger range of action.

[0142] Data base

[0143] The datums on an object can be known a priori relative to other points on the object, and to other datums, by selling or other wise providing the object designed with such knowledge to a user and including with it a CD ROM disc or other computer interfactable storage medium having this data. Alternatively, the user or someone, can teach the computer system this information. This is particularly useful when the datums are applied by the user on arbitrary objects.

[0144] **FIG. 1d**

[0145] Illustrated here are steps used in the invention relating to detection of a single point to make a command, in this case, the position (or change of position, ie movement) of a finger tip in **FIG. 12** having retroreflective target attached **1202** detected by stereo pair of TV cameras **1210**, using detection algorithm which in its simplest case is based on thresholding the image to see only the bright target indication from the finger (and optionally, any object associated therewith such as a screen to be touched for example).

[0146] If this is insufficient to unambiguously defined the datum on the finger, added algorithms may be employed which are themselves known in the art (many of which are commonly packaged with image analysis frame grabber boards such as the matrox genesis. The processes can include for example

[0147] A brightness detection step relative to surroundings, or to immediate surroundings contrast)

[0148] a shape detection step, in which a search for a shape is made, such as a circle, ring, triangle, etc.

[0149] a color detection step, where a search for a specific color is made

[0150] a movement step, wherein only target candidates which have moved from a location in a previous tv image are viewed,

[0151] Each step, may process only those passing the previous step, or each may be performed independently, and the results compared later. The orders of these steps can be changed but each adds to further identify the valid indication of the finger target.

[0152] Next the position of the targeted finger is determined by comparing the difference in location of the finger target in the two camera images of the stereo pair. There is no matching problem in this case, as a single target is used, which appears as only one found point in each image.

[0153] After the Image of finger (or other tool) tip is found, its location is computed relative to the screen or paper, and this data is inputted to the computer controlling the display to modify same, for example the position of a drawing line, an icon, or to determine a vector of movement on the screen.

[0154] Motion Detection

[0155] The computer **8** can be used to analyze incoming TV image based signals and determine which points are moving in the image This is helpful to eliminate background

data which is stationary, since often times only moving items such as a hand or object are of interest. In addition, the direction of movement is in many cases the answer desired or even the fact that a movement occurred at all.

[0156] A simple way to determine this is to subtract an image of retroreflective targets of high contrast from a first image—and just determine which parts are different—essentially representing movement of the points. Small changes in lighting or other effects are not registered. There are clearly more sophisticated algorithms as well.

[0157] Motion pre processing is useful when target contrast is not very high, as it allows one to get rid of extraneous regions and concentrate all target identification and measurement processing on the real target items.

[0158] Such processing is also useful when two camera stereo is used, as only moving points are considered in image matching—a problem when there are lots of points in the field.

[0159] Can it be assumed that the object is moving? The answer is yes if it's a game or many other activities. However there may be a speed of movement of issue. Probably frame to frame is the criteria, in a game, namely 30 Hz for a typical camera. However, in some cases movement might be defined as something much slower—eg 3 hz. for a CAD system input using deliberate motion of a designer.

[0160] Once the moving datum is identified, then the range can be determined and if the object is then tracked even if not moving from that point onward, the range measurement gives a good way to lock onto the object using more than just 2 dimensions.

[0161] One might actually use an artificial movement of the target if one doesn't naturally exist. This could be done by causing it to vibrate. If a one or more LEDs is used as a target, they can be made to blink, which also shows up in an image subtraction (image with led on, vs image with led off). The same is true of a target which changed color, showing up in subtraction of color images.

[0162] Image subtraction or other computer processing operations can also be useful in another sense. One can also subtract background, energizing the retroreflective illuminating light with no retroreflective targets present, and then with them. One idea is simply to take a picture of a room or other work space, and then bring in the targeted object. That would seem pretty simple to subtract or whatever. And the net result is that any bright features in the space which are not of concern, such as bright door knobs, glasses, etc are eliminated from consideration.

[0163] This can also be done with colored targets, doing a color based image subtract—especially useful when one knows the desired colors a priori (as one would, or could, via a teach mode)

[0164] A flow chart is shown in **FIG. 1d** illustrating the steps as follows:

[0165] A. Acquire images of stereo pair

[0166] B. Optionally preprocess images to determine if motion is present. If so, pass to next step otherwise do not or do anyway (as desired)

[0167] C. Threshold images